APPENDIX F

TREATMENT BMP DESIGN GUIDELINES

APPENDIX F TREATMENT BMP DESIGN GUIDELINES

Treatment BMP Design Guidelines

There are currently seven categories for treatment BMPs. These include biofilters, detention basins, infiltration basins, wet ponds and wetlands, drainage inserts, filtration systems, and hydrodynamic separators. Design guidelines for these categories are described below. The County may update these BMPs as needed.

F.1 Biofilters

Biofiltration swales are vegetated channels that receive directed flow and convey storm water. Biofiltration strips, also known as vegetated buffer strips, are vegetated sections of land over which storm water flows as overland sheet flow. Pollutants are removed by filtration through the grass, sedimentation, adsorption to soil particles, and infiltration through the soil. Swales and strips are mainly effective at removing debris and solid particles, although some dissolved constituents are removed by adsorption onto the soil.

Appropriate Applications and Siting Constraints:

Swales and strips should be considered wherever site conditions and climate allow vegetation to be established and where flow velocities are not high enough to cause scour. Even where strips cannot be sited to accept directed sheet flow, vegetated areas provide treatment of rainfall and reduce the overall impervious surface.

Factors Affecting Preliminary Design:

Interim criteria for the design of swales and strips include the requirements in Sections 3.1, 3.2, and 3.3 of the Guidelines. These sections direct engineers to “maximize vegetation-covered soil areas of a project,” “minimize impervious surfaces” and “minimize overland and concentrated flow depths and velocities.” Designers should also consider the following factors:
Swales have two design goals: 1) maximize treatment, 2) provide adequate hydraulic function for flood routing, adequate drainage and scour prevention. Treatment is maximized by designing the flow of water through the swale to be as shallow and long as site constraints allow. No minimum dimensions are required for treatment purposes, as this could exclude swales from consideration at some sites. Swales should also be sized as a conveyance system calculated according to County procedures for flood routing and scour.
To maximize treatment efficiency, strips should be designed to be as long (in the direction of flow) and as flat as the site will allow. No minimum lengths or maximum slopes are required for treatment purposes. The area to be used for the strip should be free of gullies or rills that can concentrate overland flow and cause erosion.
Table 5-4 summarizes preliminary design factors for biofiltration.

Table F.1: Summary Of Bio-filtration Design Factors (Strips And Swales)

Description	Applications/Siting	Preliminary Design Factors
Swales are vegetated channels that receive and convey storm water. Strips are vegetated buffer strips over which storm water flows as sheet flow. Treatment Mechanisms: • Filtration through the grass • Sedimentation • Adsorption to soil particles • Infiltration Pollutants removed: • Debris and solid particles • Some dissolved constituents	• Site conditions and climate allow vegetation to be established • Flow velocities not high enough to cause scour	• Swales sized as a conveyance system (per County flood routing and scour procedures) • Swale water depth as shallow as the site will permit • Strips sized as long (in direction of flow) and flat as the site allows • Strips should be free of gullies or rills • No minimum dimensions or slope restrictions for treatment purposes • Vegetation mix appropriate for climates and location

F.2 Detention Basins

Detention devices are impoundments where the water quality volume is temporarily detained under quiescent conditions, allowing sediment and particulates to settle out. A conceptual schematic of a detention basin is shown in Figure 5.3.1.

Detention devices remove litter, settleable solids (debris), and total suspended solids (TSS). Pollutants, such as heavy metals, that are attached (adsorbed) to the settled particulate matter will also be removed.

Appropriate Applications and Siting Constraints

Detention devices should be considered for implementation wherever site conditions allow.

One important siting requirement is that sufficient head is available so that water stored in the device does not cause a backwater condition in the storm drain system, which would limit its capacity. A second siting requirement is that seasonally high groundwater is no higher than the bottom elevation of the device for reasons described below.

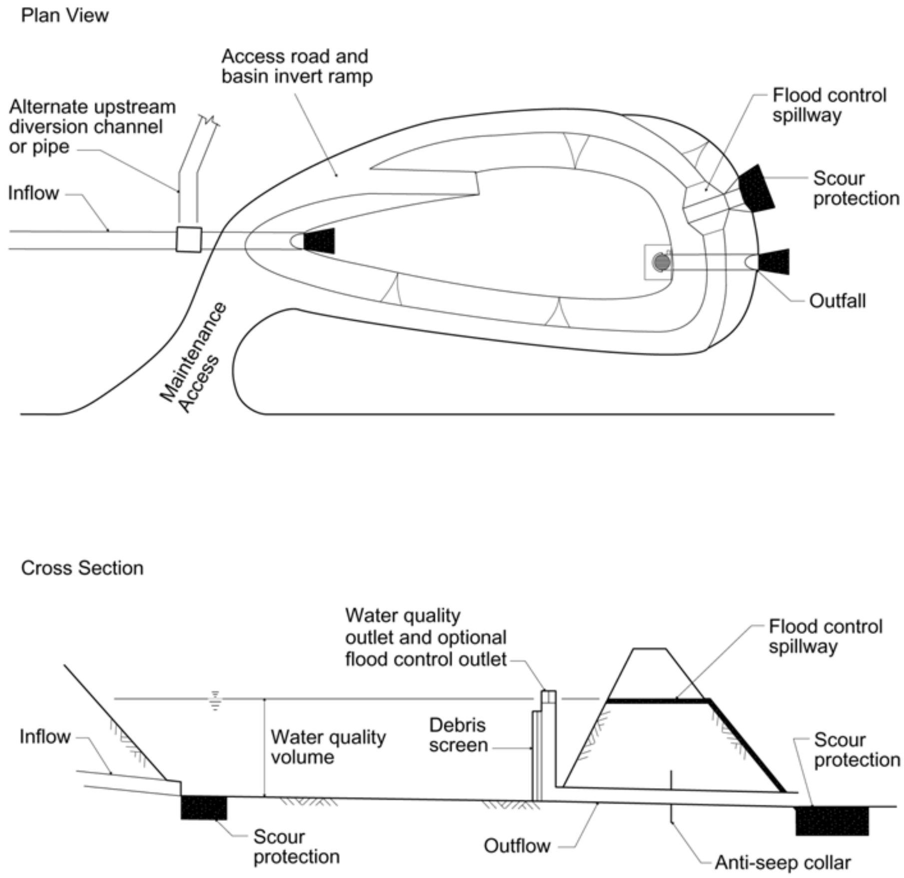


Figure F.2.1
Example of Extended Detention Basin Schematic
(Not a Standard Plan)

FACTORS AFFECTING PRELIMINARY DESIGN:

Detention devices should be designed to hold at least the 24-hour water quality volume. The maximum water level in the detention device should not cause groundwater to occur under the roadway within 0.2 m (8 inches) of the roadway subgrade. A flow-path-to-width ratio of at least 2:1 is recommended. Baffles or interior berms to accommodate the geometry of the site can accomplish this ratio.

Liners are not generally required for detention basins. Infiltration is permissible if the infiltrated water does not surface in an undesirable place off-site or threaten the stability of a slope or embankment down gradient of the basin. To protect groundwater quality and to ensure dry conditions for maintenance of unlined basins, the distance between the basin invert and seasonally high groundwater should be at least 2 m (6 ft). Where the groundwater is higher than this, the basin should be provided with an impermeable liner. In no case should the seasonally high groundwater be higher than the bottom elevation of the detention device to prevent uplift of tanks or liners.

Discharge should be accomplished through a water quality outlet. An example is shown in Figure 3.2.2. A rock pile or rock-filled gabions can serve as alternatives to the debris screen. The water quality outlet should be designed to empty the device within 24 to 72 hours. (The 24-hour limit is chosen to provide adequate settling time; the 72-hour limit is chosen to minimize the potential for mosquito breeding.) Because detention basins are not maintained for infiltration, water loss by infiltration should be disregarded when designing the hydraulic capacity of the outlet structure.

Public health and vector control authorities should be consulted to verify the acceptability of detention basins and the maximum drawdown time allowed to avoid mosquito problems.

The inlet structure of the basin should be designed to divert the peak hydraulic flow (calculated according to County procedures for flood routing and scour) when the basin is full. Alternatively, an overflow structure sized according to these criteria can be provided in one of the downstream walls or berms. A third alternative is to include a flood control outlet in the top of the water quality outlet. In this case, an additional outlet (riser or spillway) should be supplied to prevent overtopping of the walls or berms. Entering flows should be distributed uniformly at low velocity to prevent re-suspension of settled materials and to encourage quiescent conditions.

The site must have sufficient area for a perimeter maintenance road and safe access to and from the site from local roads. Basin side slopes must be shallow enough to permit tracked vehicles to access the basin bottom for maintenance. Alternatively, an access ramp should be provided. Preliminary design factors for detention basins are summarized in Table 3.2.1.

Table F.2 Summary Of Extended Detention Basin Design Factors

Description	Applications/Siting	Preliminary Design Factors
Impoundments where the water quality volume is temporarily detained Treatment Mechanisms: • Sedimentation • Infiltration (if basin unlined) Pollutants removed: • Sediment and particulates • Litter • Sorbed pollutants (heavy metals, O&G)	• Sufficient head to prevent backwater condition in the storm drain system • Seasonally high groundwater below basin invert • Consult public health and vector control authorities	• Size to capture the 24-hr water quality volume • Flow-path-to-width ratio of at least 2:1 recommended • Maximum water level should not cause groundwater to occur under the roadway within 0.2 m of the roadway subgrade • Basin invert ≥ 2 m above seasonally high groundwater or else a impermeable liner is required • Scour protection on inflow, outfall and spillway • Maintenance access (road around basin and ramp to basin invert) • Upstream diversion channel or pipe, downstream overflow structure or flood control outlet • Discharge through a water quality outlet with debris screen (or equivalent) • Outlet design to empty basin within 24 to 72 hrs • Flows should enter at low velocity

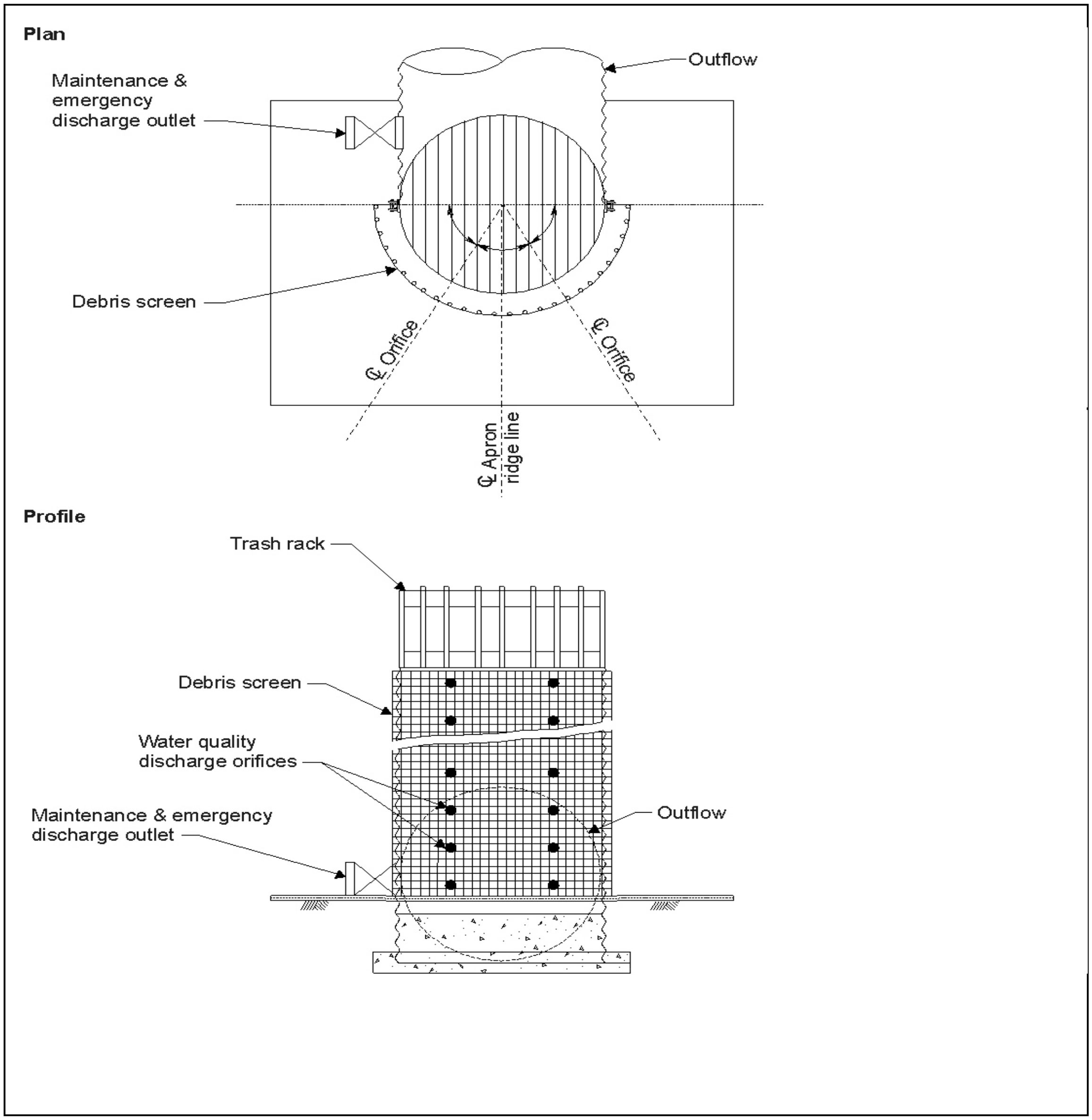


Figure F.2.2
Detention Basin Outlet Structure Schematic
(Not a Standard Plan)

E.3 Infiltration Basins

Infiltration basins are depressions designed to hold runoff and infiltrate it directly to the soil rather than discharging it to receiving waters. A conceptual schematic illustration of an infiltration basin is shown in Figure F.3.

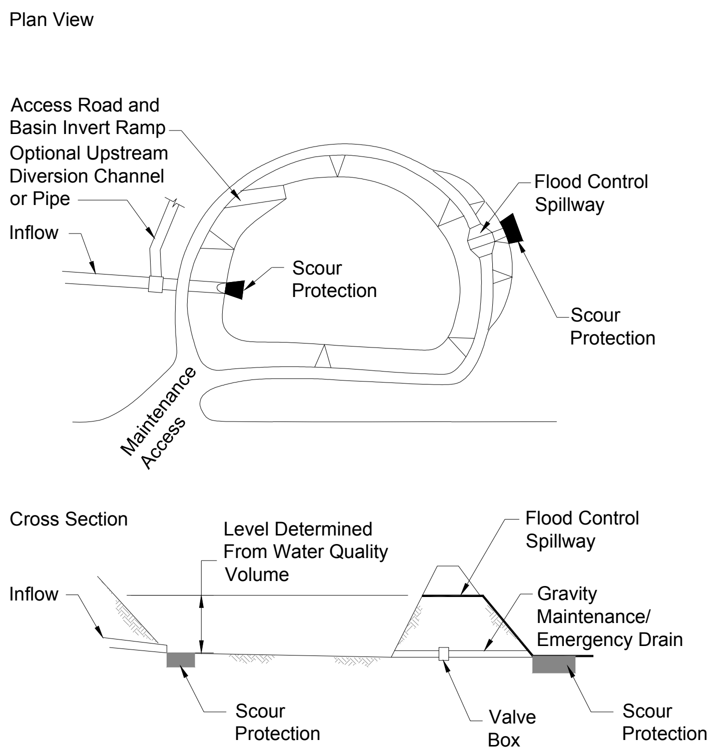


Figure F.3
Example Conceptual Schematic of Infiltration Basin Design (Not a Standard Plan)

Appropriate Applications and Siting Constraints:

Infiltration basins should be considered wherever site conditions allow and the design water quality volume exceeds 0.1 acre-feet. Appropriate sites for infiltration basins have sufficient soil permeability (both vertical and horizontal), have a sufficiently low water table, do not present a threat to local groundwater quality and are at a sufficient elevation to allow gravity drainage (of the basin) for maintenance purposes.

The following steps are recommended for determining the feasibility of infiltration BMPs. The major components are Pre-screening, Site Screening, Site Investigation and Preliminary Design.

1. Pre-Screening for the Infiltration BMP

Pre-screening for the infiltration BMP involves collecting site-specific information necessary to determine, in consultation with the RWQCB, whether infiltration is an appropriate storm water treatment for the site. No field-testing is anticipated during this phase. The steps involved in pre-screening include:

1. Information collection; and
2. Preliminary determination of infiltration appropriateness through consultation with RWQCB on the results.

The following sections describe the steps involved.

Information Collection

Some of the basic site-specific data required for the determination of the appropriateness of the infiltration BMP are found in the sources listed below. Additional data may be required for local conditions. Data collected by the project engineer or proponent include, but may not be limited to:

- Outfall inventory data (if available), project alignment, right-of-way, annual average daily traffic (ADT), outfall locations, and other basic project maps and data;
- Tributary drainage areas and surrounding land uses (from outfall inventory, as-builts, aerial photographs, GIS data from the County and local planning agencies);
- Site surface hydrology data: tributary drainage area, runoff coefficients, drainage network, travel times, etc., needed to design facilities to the County's hydrologic/hydraulic criteria;
- Basin Plan groundwater beneficial uses and known impairments (RWQCB);
- If available, runoff quality data for appropriate land use in catchment area;
- Water quality treatment volume per County SUSMP;
- Site soil characteristics:
    - Indigenous soil types: NRCS soil maps and corresponding hydrologic soil classes;
    - Soil infiltration rates (estimated and from any existing on-site testing in the vicinity by others); and

- Project grading plans or as-built plans (if retrofit), if available.

- Existing groundwater and hydrogeology information:
  - Maps of local aquifers underlying the alignment or location of the proposed project;
  - Aquifer groundwater quality and seasonal groundwater levels: monitoring well data, U.S. Geological Survey (USGS), Department of Water Resources (DWR), and local public agency maps and databases;
  - Local groundwater quality concerns: Consult RWQCB, California Department of Health Services (DHS), local environmental/health department (city/county);
  - Site hydrogeology (from any existing boring logs: lenses, hardpan, etc.);
  - Known contaminated groundwater plumes (RWQCB); and
  - Groundwater rights data: adjudicated basins, other rights (RWQCB, DHS); and
- State Water Information Management System data for project area (SWRCB).

During the data collection process, the proponent should brief the RWQCB regarding the project for which the BMP is being considered, and request assistance in the data collection process as needed.

Preliminary Determination for Appropriateness of Infiltration

Once the data above have been collected and placed in the context of the alignment and/or location of the facility being considered for infiltration BMPs, the project engineer will use the data collected and follow the procedure outlined in below.

Salient steps include:

1. Determine if the San Diego Basin Plan or other local ordinances provide influent limits on quality of water that can be infiltrated. Compare with runoff quality, and determine if infiltration is permissible. If not, consider detention basins.
2. Determine if local agencies, public health authorities, legal restrictions, or other concerns preclude consideration of infiltration of storm water runoff. Consult with RWQCB and representatives of appropriate authorities as needed. If infiltration into the aquifer is not acceptable to local authorities, consider detention basins.
3. Estimate the quality of runoff from the facility draining into the proposed infiltration basin using data from a storm water database and/or annual

research summaries.

Compare the estimated runoff water quality with available groundwater quality data, using receiving water objectives from the RWQCB Basin Plan for each groundwater beneficial use. Determine if the separation between the maximum anticipated seasonal high groundwater and the proposed basin invert is at least 3 m (10 ft). Tabulate the results and make a preliminary determination of the appropriateness of the infiltration BMP.

4. Contact the RWQCB to review procedures followed, what information is available and what information is not available. Present the compiled data and the results of the preliminary determination to the RWQCB.
5. The County will jointly review the data, and, if necessary, gather additional existing information if available data are deemed insufficient for a preliminary determination. The County will then re-convene to make the determination on whether to proceed with infiltration.

If the determination is negative (infiltration *not* appropriate), consider detention basins. If determination is positive (infiltration potentially appropriate), proceed to infiltration site screening.

2. Site Screening

Using data gathered in the pre-screening process, perform an initial desktop screening of sites to narrow the number of potential sites to those that can be considered for field investigations. As needed, collect additional information, and follow the procedures below:

- Estimate soil type (consider NRCS Hydrologic Soil Groups (HSG) A, B, or C only, as shown in Table 5-4) from soil maps and/or USDA soil survey tables and/or background information; in areas where septic systems are in widespread use, the County Environmental Health Department should have information on appropriate soil types for infiltration of onsite wastewaters.

TABLE F-4: TYPICAL INFILTRATION RATES FOR NRCS TYPE AND HSG CLASSIFICATIONS

NRCS Soil Type	HSG Classification	Infiltration Rate cm/hr	Infiltration Rate (in/hr)
Sand	A	2.0	(8.0)
Loamy sand	A	5.1	(2.0)
Sandy loam	B	2.5	(1.0)
Loam	B	1.3*	(0.5)*
Silt loam	C	0.6	(0.25)
Sandy clay loam	C	0.4	(0.15)
Clay loam & silty clay loam	D	<0.2	(<0.09)
Clays	D	<0.1	(<0.05)

* Minimum rate for infiltration basins. Silt loams may also be acceptable (HSG C) if geotechnical investigations demonstrate adequate infiltration rates.

- Also review other key available data: percent silt and clay, presence of a restrictive layer, permeable layers interbedded with impermeable layers, and seasonal high water table. Other geotechnical considerations include location in seismic impact zones, unstable areas, such as landslides and Karst terrains, and those with soil liquefaction and differential settlement potential. Generally, sites should not be constructed in fill, or on any slope greater than 15 percent.
- The minimum acceptable spacing between the proposed infiltration basin invert and the seasonal high water table is 3 m (10 feet). If a separation of less than 3 m (10 feet) is proposed, the approval of the local RWQCB is required.
- Infiltration basins should not be sited in locations over previously identified contaminated groundwater plumes. Setback distance should be determined in coordination with the RWQCB.
- Estimate infiltration rate for maximum infiltration for soil type using Table F-4.
- Estimate the area required for infiltration as follows:

$$A_{est} = 12 \cdot SF \cdot WQV / k_{est} \cdot t \qquad \text{(Eq. 1)}$$

Where:

A_{est}	=	estimated area of invert of basin, ft^2
12	=	conversion factor from inch to feet
SF	=	safety factor of 2.0
WQV	=	water quality volume calculated from the design storm, ft^3
k_{est}	=	estimated infiltration rate from Table 5-4, in/hr
t	=	draw-down time, 48 hours

- The infiltration basin should be located outside the 9 m (30 ft) clear recovery zone, 300 m (1,000 ft) from any municipal water supply well, 30 m (100 ft) from any private well, septic tank or drain field, and 60 m (200 ft) from a Holocene fault zone.

3. Site Investigation

1. Obtain list of candidate sites (within project limits) that pass the screening process, if available).
2. Perform site investigation to identify any: (a) Regulatory permit required, (b) major underground utility interference, (c) Transportation improvement plan conflicts, or (d) General plan land use data for tributary area.
3. If the parcel is outside of R/W, for planning to proceed, it must generate greater than 50% of the total tributary runoff. Otherwise discontinue investigation of parcel.
4. Assess the feasibility (degree of plumbing and available area) of directing runoff from additional tributary area to the site (other off-site areas are secondary). Consider potential downstream impacts from diversions and cost of diverting additional flow. Diversions of tributary area to unimproved conveyances (creeks/streams) is prohibited. Diversions to improved conveyances may be permitted if it can be demonstrated that the conveyance has sufficient capacity to accommodate the additional flow.
5. Investigate feasibility of infiltration using criteria above and procedure in Section 4: Procedure for preliminary infiltration basin site investigation. Recalculate and verify area requirements using the collected field data. Use Equation 1 above and the lowest measured infiltration rate to calculate area of basin.
6. If an infiltration basin is feasible, proceed to Section 5 Preliminary Design.

4. Procedure for Preliminary Infiltration Basin Site Investigation

The following scope of work defines the steps for infiltration basin feasibility studies. This scope of work provides for a level of investigation necessary to determine if an infiltration basin may be feasible on the subject site. The screening procedure is terminated if the site does not meet the criteria for any step, and assessment of the site continues for a detention basin.

The depth to groundwater must be known as the first step in feasibility because a high groundwater table can lead to infiltration failure and potential contamination of the groundwater table. The *in situ* infiltration rate at the basin invert must also be known to ensure that infiltration of the calculated water quality volume is possible within 48 hours. Due to the extreme variability of site conditions, field investigation is required to determine the depth to groundwater and *in situ* infiltration rate.

The scope of work comprises two phases:

- Initial Investigation; and
- Detailed Investigation as described below.

Initial Investigation

The initial investigation comprises two parts: A) Initial technical field screening and determination of groundwater elevations, and B) Geotechnical investigation for soil lithology and select chemical testing. To streamline the initial investigation phase, Part A will be performed first, followed by Part B if the Part A criterion of at least 3 m (10 ft) clearance for the groundwater elevation below the basin invert is satisfied and the engineer approves the site for further consideration. Consult the local RWQCB for approval of proposed groundwater separation less than 3 m (10 ft).

Part A Initial Technical Field Screening and Determination of Groundwater Elevation

An initial indication of the seasonal high groundwater water table elevation will be determined by using a piezometer, previous studies, or other accepted geotechnical means. The piezometer will be installed to a depth of at least 6 m (20 ft) below the proposed basin invert using the direct push or other suitable method. Groundwater levels will be observed for at least 24 hours after installation. As part of this task, an engineer will conduct a site reconnaissance to evaluate the site conditions. Site screening criteria in Section 2 should be considered.

A regional groundwater review will be performed based on the available data, including, but not necessarily limited to:

- Previously compiled databases on potential BMP sites (such as outfall inventory databases);
- Data and maps available from regional government databases, DWR, and the County sources;
- Local soil survey data from the NRCS and other sources;
- Soil lithology, infiltration rate and groundwater depth data from the County or other specialists that approve septic system installations in the local area;
- Information on local groundwater beneficial uses and groundwater quality issues from the RWQCBs and other water agencies; and
- Information on local groundwater-related drinking water issues from DEH.

The geotechnical professional will make a determination on a site-by-site basis, whether the groundwater elevation determined after 24 hours can be considered to be a reasonable indication of the seasonal high water table for the purposes of the evaluation of the groundwater depth criteria, described below. If such determination cannot be made reasonably based on the available data, the site will be recommended for a longer period of water table elevation monitoring, as necessary.

If the initial seasonal high groundwater elevation indication is within 3 m (10 ft) of the invert of the proposed infiltration basin, the site will be eliminated from further consideration unless the local RWQCB requires installation of an infiltration basin with less than 3m separations to groundwater, and that provides adequate groundwater protection. If there is not a reliable indication that the seasonal high water table is at least 3 m (10 ft) below the invert of the proposed infiltration basin (i.e., if there is reason to believe the water table may rise to within 3 m (10 ft) of the proposed invert), a more extensive groundwater table elevation investigation will be performed as outlined below in Part 2.C of the Detailed Investigation procedure described below. If the groundwater elevation at the site clearly exceeds 3 m (10 ft) from the proposed basin invert and all other criteria in the initial investigation are satisfied, a detailed groundwater elevation determination will not be required.

Part B Geotechnical Investigation for Soil Lithology and Select Chemical Testing

An initial soil investigation will be performed to adequately understand soil lithology and determine:

- If there are potential problems in the soil structure that would inhibit the rate or quantity of infiltration desired; or
- If there are potential adverse impacts that could result from locating the infiltration basin at the site to either structures, slopes or groundwater.

Geotechnical trenches (or at the option of the engineer, a boring may be used) will be dug using a backhoe at one or two locations within each site, depending on the site conditions. Clearance of the site for hazardous contaminants through the appropriate District should be done prior to drilling by the geotechnical professional conducting the work. Underground Service Alert (USA) clearance will also be obtained. The trenches will be at least 2 m (6 ft) long and 2 m (6 ft) deep below the proposed basin invert. The soil profiles will be carefully logged to determine variations in the subsurface profile. Of greatest importance is the presence of fine-grained materials such as silts and clays, which should be determined by direct measurement of particle size distribution. It is anticipated that two to four soil samples will be collected for determination of the soil particle size distribution at each site. Samples will be collected from the soil profiles at different horizons and transported to a laboratory for soil texture and chemical testing as described below:

- Soil textures that tend to promote infiltration include sands, loamy sands, sandy loams, and loams (and possibly some of the coarser silt loams) in the NRCS classification system, or GW, GM, SP, SW and GC, SC, SM, ML (unified soil classification), subject to clay and clay/silt percentages shown below and the judgment of the field engineer or soil scientist.
- The soil in the first 300 mm (12 inches) below the basin invert will be tested for organic content (OC), pH, and cation exchange capacity (CEC). Values that promote pollutant capture in the soil are: OC > 5 percent, pH in the range of 6-8, and CEC > 5 meq/100 g of soil. In general, the soil should not have more than 30 percent clay or more than 40 percent of clay and silt combined.

In addition, the trenches should be examined for other characteristics that may adversely affect infiltration. These include evidence of significant mottling (indicative of high groundwater), restrictive layer(s), and significant variation in soil types horizontally and vertically. A summary report will be prepared addressing the issues noted above, with recommendations on the suitability of the site for infiltration and the necessity of carrying out the next phase of the investigation. (All the site reports will ultimately be combined in a single report.) Caltrans will give the 'go/no go' instructions for the detailed investigation phase for the sites deemed acceptable from the initial investigation.

Detailed Investigation

If the site conditions still appear favorable to infiltration after the geotechnical review and soil investigations, a detailed field investigation will be undertaken, which includes Part A, Detailed Subsurface Soil Investigation, Part B, In-Hole Conductivity Testing, and Part C, Detailed Groundwater Elevation Determination.

Part A Detailed Subsurface Soil Investigation

Borings will be drilled to a maximum depth of 15 m (50 ft) (or refusal) for each detailed investigation location at the discretion of the geotechnical professional. Samples will be obtained at 1.5 m (5-ft) intervals for soil characterization and laboratory testing. Bulk samples will also be collected at shallow depths to verify information collected in Parts A and B of the Initial Investigation.

Part B In-hole Conductivity Testing

Infiltration rate tests or another method approved by the geotechnical engineer will be performed at the proposed basin invert. The tests will be located to measure infiltration rates in the bed of the proposed basin.

The minimum acceptable infiltration rate as measured in any of the test holes is 1.3 cm/hr (0.5 in/hr). If any test hole shows less than the minimum value, the site will be disqualified from further consideration. If the infiltration rate at the site is significantly greater than 6.4 cm/hr (2.5 in/hr), the RWQCB must be consulted, and the RWQCB must conclude that the groundwater quality will not be compromised, before approving the site for infiltration.

If the site is constructed in fill or partially in fill, it will be excluded from consideration unless no silts or clays are present in the soil boring. Fill tends to be compacted, with clays in a dispersed, rather than flocculated state, greatly impacting permeability.

The geotechnical investigation will be sufficient to develop a good understanding of how the storm water runoff will move in the soil (horizontally or vertically), and if there are any geological conditions that could inhibit the movement of water.

Part C Detailed Groundwater Elevation Determination

If a detailed investigation to determine the groundwater elevation is required per the guidance above and, in the opinion of the engineer, the seasonal high groundwater elevation may come within 3 m (10 ft) of proposed basin invert) at least one and possibly two (per the recommendation of the geotechnical engineer) groundwater monitoring wells will be installed. One well will be installed within the proposed basin footprint and the other, if needed, will be installed near the basin but downgradient by about 10 m (30 feet). The wells will be observed over a wet and dry season. This observation period will be extended to a second wet season (at the direction of the County) if the first wet season produces rainfall less than 80% of the historical average. The minimum acceptable spacing between the proposed infiltration basin invert and the seasonal high water table, as measured at either of the two established monitoring wells, is 3 m (10 ft), unless, in coordination with the RWQCB, it can be demonstrated that the groundwater will not be adversely impacted. A geotechnical professional will oversee the detailed investigation and must also consider other potential factors that may influence the groundwater elevation, such as local or regional groundwater recharge projects, future urbanization or agriculture. The geotechnical professional shall also examine the soil borings for indications of previous high water.

A final geotechnical report, overseen by a geotechnical professional, summarizing the findings of the investigation will be prepared. The report will include all results from the initial as well as detailed investigation phases of the feasibility study.

5. Preliminary Design

Table F-5 summarizes preliminary design factors for infiltration basins.

1. Obtain site topography (one-half meter contours, 1:500 scale). Extend topography 25 m beyond the site perimeter in all directions and along the drain line to the location of the outfall to the local receiving water.

2. Develop a conceptual grading plan for improvements showing basin, maintenance access, basin outlet and extent of R/W requirements to accommodate the improvements. The basin invert must not have a slope of greater than 3%.
3. Develop unit cost-based cost estimate to construct the infiltration basin. Include allowances for hazardous/unsuitable materials, traffic management, storm drain system improvements (as needed and determined by engineer).
4. Develop single paragraph assessments of: nonstandard design features, impact on utilities, hydrology (WQV, peak flow, land use), R/W total area needed, current ownership), planting and lighting, permits, hazardous materials, environmental clearance and traffic management.

TABLE F.5: SUMMARY OF INFILTRATION BASIN SITING AND DESIGN CRITERIA

Description	Applications/Siting	Preliminary Design Factors
Depressions designed to hold runoff and infiltrate into the soil without discharge Treatment Mechanism: • Infiltration Pollutants removed: • All constituents	• > 3 m (w ft) to seasonally high water table (≥ 1.2 m [4 ft] if justified by adequate groundwater observations for a minimum of 1 year) • Soil infiltration rate ≥ 1.3 cm/hr (0.5 in/hr) • Clay content < 30%, and < 40% clay and silt combined • Sufficient horizontal hydraulic capacity • Infiltrated water is unlikely to affect the stability of downgradient structures, slopes, or embankments • Runoff quality is ≥ standards for infiltration to local groundwater • If pretreatment is required, only approved BMPs should be considered • Consult with RWQCB, water agencies, vector control authorities, and local utilities	• Maintenance access (road around basin and ramp to basin invert) • Optional upstream diversion channel or pipe, or downstream overflow structure • Flood control spillway • Scour protection on inflow and spillway • Size to capture the 24-hr water quality volume • Infiltrate water quality volume within 48 hours • Use ½ the measured infiltration rate to size the basin • > 3 m downgradient and 30 m (100 ft) upgradient from structural foundations • ≥ 30 m (100 ft) from drinking water wells • Emergency/maintenance gravity drain

F.4 Wet Ponds and Wetlands

(This information is derived from the Los Angeles County SUSMP)

DESCRIPTION

Wetlands provide physical, chemical, and biological water quality treatment of stormwater runoff. Physical treatment occurs as a result of decreasing flow velocities in the wetland, and is present in the form of evaporation, sedimentation, adsorption, and/or filtration. Chemical processes include chelation, precipitation, and chemical adsorption. Biological processes include decomposition, plant uptake and removal of nutrients, plus biological transformation and degradation. Hydrology is one of the most influential factors in pollutant removal due to its effects on sedimentation, aeration, biological transformation, and adsorption onto bottom sediments (Dormann, et al., 1988). The large surface area of the bottom of the wetland encourages higher levels of adsorption, absorption, filtration, microbial transformation, and biological utilization than might normally occur in more channelized water courses.

A natural wetland is defined by examination of the soils, hydrology, and vegetation which are dominant in the area. Wetlands are characterized by the substrate being predominantly undrained hydric soil. A wetland may also be characterized by a substrate, which is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. Wetlands also usually support hydrophytes, or plants which are adapted to aquatic and semi-aquatic environments. Natural and artificial wetlands are used to treat stormwater runoff. Figure 1 illustrates an artificial wetland used for treating stormwater runoff.

The success of a wetland will be much more likely if some general guidelines are followed. The wetland should be designed such that a minimum amount of maintenance is required. This will be affected by the plants, animals, microbes, and hydrology. The natural surroundings, including such things as the potential energy of a stream or a flooding river, should be utilized as much as possible. It is necessary to recognize that a fully functional wetland cannot be established spontaneously. Time is required for vegetation to establish and for nutrient retention and wildlife enhancement to function efficiently. Also, the wetland should approximate a natural situation as much as possible, and unnatural attributes, such as a rectangular shape or a rigid channel, should be avoided (Mitsch and Gosselink, 1993).

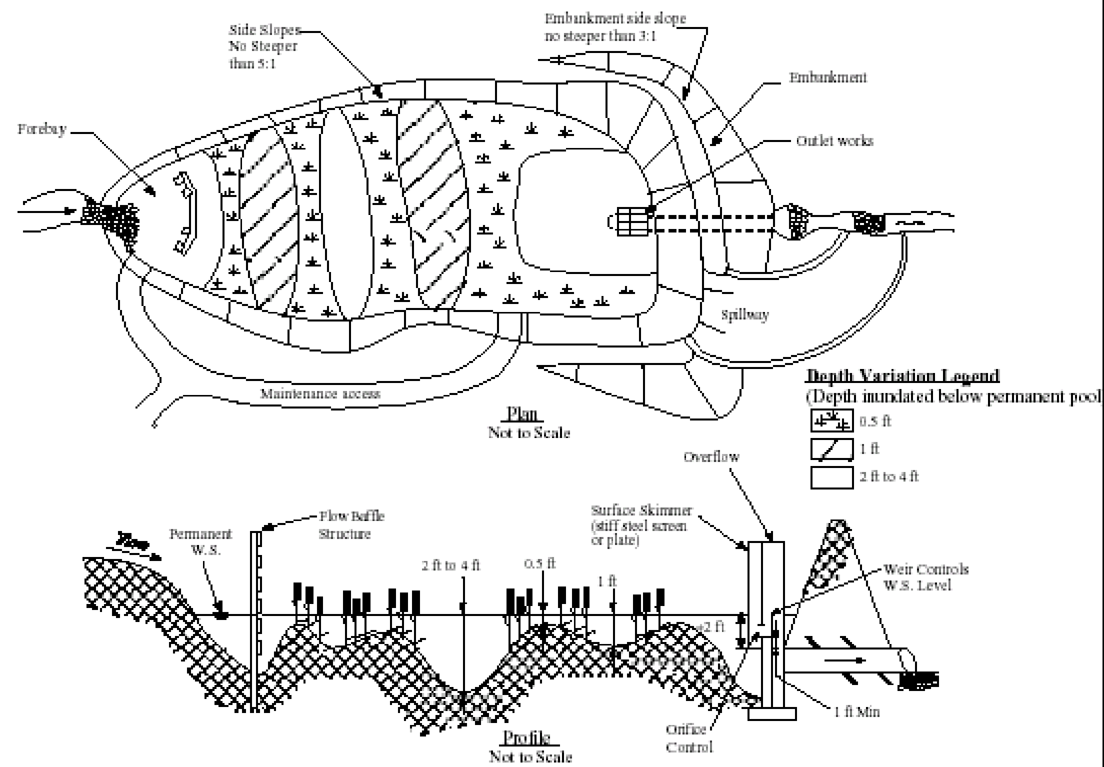


Figure 1. Plan and profile of a wetland pond (adapted from Urbanos, 1992).

1. *Natural Wetland Systems*. If a natural wetland site is potentially available for use to treat stormwater runoff, an assessment should be done to determine whether treatment of stormwater runoff would be appropriate. Important characteristics to look for in a potential natural wetland site include the wetland vegetation, the type of wetland, the existing wetland hydrology, and the geomorphology at the potential site.

   Wetland vegetation can be categorized as either emergent, floating, or submerged. Emergent vegetation is rooted in the sediments, but grows through the water and above the water surface. Floating vegetation is not rooted in the sediments, and has aquatic roots with plant parts partly submerged or fully exposed on the water or surface. Submerged vegetation includes aquatic plants such as algae or plants rooted in the sediments, with all plant parts growing within the water column. Pollutant removal rates generally improve with an increase in the diversity of the vegetation.

   The depth of inundation will contribute to the pollutant removal efficiency. Generally, shallow water depths allow for higher pollutant removal efficiencies due to an increased amount of adsorption onto bottom sediments (Dormann, et al., 1988). The water budget of the wetland should be calculated to determine the mean residence time of the wetland, assuming there is no change in storage. Water budget calculations should include precipitation, overland flow from other sources, groundwater, evapotranspiration, and any stormwater runoff into and out of the wetland. Flow patterns in the wetland will affect the removal efficiency also. Meandering channels, slow-moving water and a large surface area will increase pollutant removal through increased sedimentation. Shallow, sheet flow also increases the pollutant removal capabilities, through assimilative processes. A deep pool sometimes improves the denitrification potential. A mixed flow pattern will increase overall pollutant removal efficiency (Dormann, et al., 1988).

2. *Artificial wetlands.* Site considerations should include the water table depth, soil/substrate, and space requirements. Because the wetland must have a source of flow, it is desirable that the water table is at or near the surface. This is not always possible. If runoff is the only source of inflow for the wetland, the water level often fluctuates and establishment of vegetation may be difficult. The soil or substrate of an artificial wetland should be loose loam to clay. A perennial base flow must be present to sustain the artificial wetland. The presence of organic material is often helpful in increasing pollutant removal and retention.

   Using a site where wetlands previously existed or where nearby wetlands still exist is recommended if possible. A hydrologic study should be done to determine if flooding occurs and saturated soils are present. A site where natural inundation is frequent is a good potential site (Mitsch and Gosselink, 1993). Loamy soils are required to permit plants to take root (Urbonas, 1992)

ADVANTAGES

1. Artificial wetlands offer natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal.
2. Artificial wetlands can offer good treatment following treatment by other BMPs, such as wet ponds, that rely upon settling of larger sediment particles (Urbonas, 1992). They are useful for large basins when used in conjunction with other BMPs.
3. Wetlands which are permanently flooded are less sensitive to polluted water inflows because the ecosystem does not depend upon the polluted water inflow.
4. Can provide uptake of soluble pollutants such as phosphorous, through plant uptake.
5. Can be used as a regional facility.

LIMITATIONS

1. Although the use of natural wetlands may be more cost effective than the use of an artificial wetland; environmental, permitting and legal issues may make it difficult to use natural wetlands for this purpose.
2. Wetlands require a continuous base flow.
3. If not properly maintained, wetlands can accumulate salts and scum which can be flushed out by large storm flows.
4. Regular maintenance, including plant harvesting, is required to provide nutrient removal.
5. Frequent sediment removal is required to maintain the proper functioning of the wetland.
6. A greater amount of space is required for a wetland system than is required for an extended/dry detention basin treating the same amount of area.
7. Although artificial wetlands are designed to act as nutrient sinks, on occasion, the wetland may periodically become a nutrient source.
8. Wetlands which are not permanently flooded are more likely to be affected by drastic changes in inflow of polluted water.
9. Cannot be used on steep unstable slopes or densely populated areas.
10. May be regulated under Chapter 15, Title 23, California Code of Regulations regarding waste disposal to land.
11. Threat of mosquitoes.
12. Hydraulic capacity may be reduced with plant overgrowth.

DESIGN CRITERIA

The wetland may be designed as either a stand-alone BMP, or as part of a larger non-point source treatment facility in conjunction with other devices, such as a wet pond, sediment forebay, or infiltration basin. Basic design elements and considerations are listed below.

1. *Volume.* The wetland pond should provide a minimum permanent storage equal to three-fourths of the water quality control volume. The full water quality capture volume should be provided above the permanent pool. Calculate the water quality volume to be mitigated by the wetland using the County of San Diego Standard Urban Storm Water Mitigation Plan, Treatment Control BMPs, Principle 8: Design to Treatment Control Standards. *Volumes Based on 0.6-inches of Rainfall*.

2. *Depth.* A constant shallow depth should be maintained in the wetland, at approximately 1 ft or less (Schueler, 1987; Boutiette and Duerring, 1994), with 0.5 ft being more desirable (Schueler, 1987). If the wetland is designed as a very shallow detention pond, the pond should provide the full water quality capture volume above the permanent pool level. The permanent wetland depth should be 6 to 12 inches deep. The depth of the

water quality capture volume above the permanent pool should not exceed 2 ft (Urbonas, 1992). Regrading may be necessary to allow for this shallow depth over a large area.

It may also be beneficial to create a wetland with a varying depth. A varying depth within the wetland will enable more diverse vegetation to flourish. Deep water offers a habitat for fish, creates a low velocity area where flow can be redistributed, and can enhance nitrification as a prelude to later denitrification if nitrogen removal is desired. Open-water areas may vary in depth between 2 and 4 ft (Urbonas, 1992).

3. *Surface Area.* Increasing the surface area of the pond increases the nutrient removal capability (Boutiette and Duerring, 1994). A general guideline for surface area is using a marsh area of two to three percent of the contributing drainage area. The minimum surface area of the pond can also be calculated by determining the nutrient loading to the wetland. The nutrient loading to a wetland used for stormwater treatment should not be more than 45 lbs/ac of phosphorus or 225 lbs/ac of nitrogen per year. The pond could be sized to meet this minimum size requirement if the annual nutrient load at the site is known (Schueler, 1987).

4. *Longitudinal Slope.* Both wetland ponds and channels require a near-zero longitudinal slope (Urbonas, 1992).

5. *Base flow.* Enough inflow must be present in the wetland to maintain wetland soil and vegetation conditions. A base flow should be used. Dependence on groundwater for a moisture supply is not recommended.

6. *Seeding.* It is important that any seed that is used to establish vegetation germinate and take root before the site is inundated, or the seeds will be washed away.

7. *Length to Width Ratio.* The pond should gradually expand from the inlet and gradually contract toward the outlet. The length to width ratio of the wetland should be 2:1 to 4:1 with a length to width ratio of 3:1 recommended (Urbonas, 1992)

8. *Emptying Time.* The water quality volume above the permanent pool should empty in 24 hours (Urbonas, 1992). This emptying time is not for the wetland itself, but for the additional storage above the wetland.

9. *Inlet and Outlet Protection.* Inlet and outlet protection should be provided to reduce erosion of the basin. Velocity should be reduced at the entrance to reduce resuspension of sediment by using a forebay. The forebay should be approximately 5 to 10 percent of the water quality capture volume. The outlet should be placed in an offbay at least 3 ft deep. It may

be necessary to protect the outlet with a skimmer shield that starts approximately one-half of the depth below the permanent water surface and extends above the maximum capture volume depth. A skimmer can be constructed from a stiff steel screen material that has smaller openings than the outlet orifice or perforations.

10. *Infiltration Avoidance.* Loss of water through infiltration should be avoided. This can be done by compacting the soil, incorporating clay into the soil, or lining the pond with artificial lining.

11. *Side Slopes.* Side slopes should be gradual to reduce erosion and enable easy maintenance. Side slopes should not be steeper than 4:1, and 5:1 is preferable (Urbonas, 1992).

12. *Open Water.* At least 25 percent of the basin should be an open water area at least 2 ft deep if the device is exclusively designed as a shallow marsh. The open water area will make the marsh area more aesthetically pleasing, and the combined water/wetland area will create a good habitat for waterfowl (Schueler, 1987). The combination of forebay, outlet and free water surface should be 30 to 50 percent, and this area should be between 2 and 4 ft deep. The wetland zone should be 50 to 70 percent of the area, and should be 6 to 12 inches deep (Urbonas, 1992).

13. *Freeboard.* The wetland pond should be designed with at least 1 ft of freeboard (Camp, Dresser and McKee, 1993).

14. *Use with Wet Pond.* Shallow marshes can be established at the perimeter of a wet pond by grading to form a 10 to 20 ft wide shallow bench. Aquatic emergent vegetation can be established in this area. A shallow marsh area can also be used near the inflow channel for sediment deposition (Schueler, 1987).

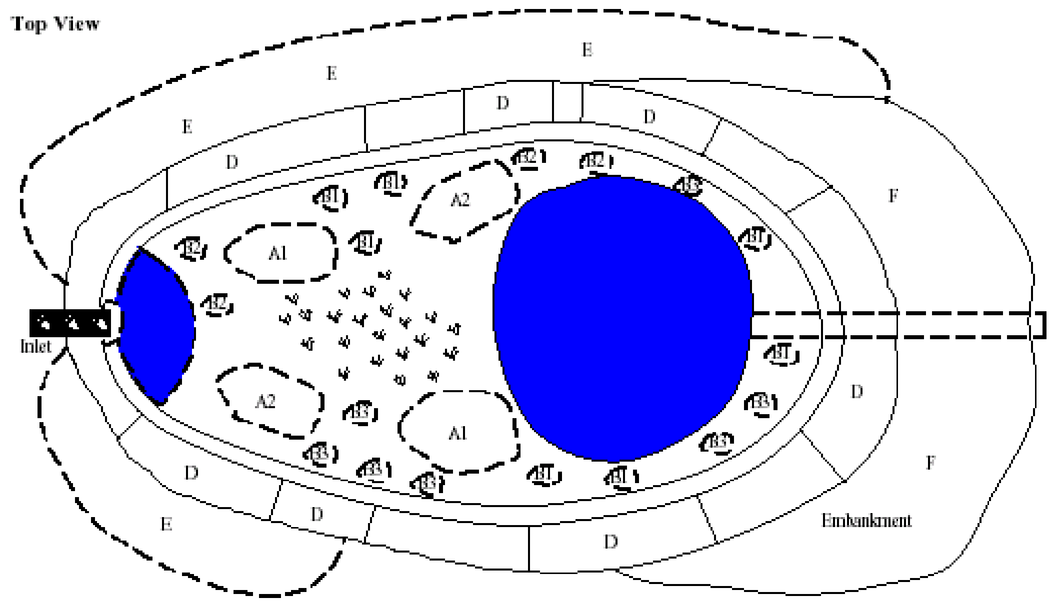
15. *Shape.* The shape is an important aspect of the wetland. It is recommended that a littoral shelf with gently sloping sides of 6:1 or milder to a point 24 to 28 inches below the water surface (Mitsch and Gosselink, 1993). Bottom slopes of less than one percent slope are also recommended.

16. *Soils*. Clay soils underlying the wetland will help prevent percolation of water to groundwater. However, clay soils will also prevent root penetration, inhibiting growth. Loam and sandy soils may then be preferable. A good design may be use of local soils at the upper layer with clay beneath to prevent infiltration (Mitsch and Gosselink, 1993).

17. *Vegetation.* Vegetation must be established in the wetland to aid in slowing down velocities, and nutrient uptake in the wetland. A dependable

way of establishing vegetation in the wetland is to transplant live plants or dormant rhizomes from a nursery. Emergent plants may eventually migrate into the wetland from upstream, but this is not a reliable source of vegetation. Transplanting vegetation from existing wetland areas is not encouraged, as it may damage the existing wetland area. Seeding is more cost effective, but is also not reliable.

Plants, which should be planted on the wetland bottom, include cattails, sedges, reeds, and wetland grasses. Berms and side-slopes should be planted with native or irrigated turf-forming grasses. To allow the vegetation to establish, it may be necessary to initially lower the permanent pool, perhaps 3 to 4 inches.



LEGEND
A1: Primary Wetland Species
A2: Primary Wetland Species
B1: Secondary Wetland Species
B2: Secondary Wetland Species
B3: Secondary Wetland Species
C: Deep Open Water Areas (No Vegetation)
D: Shoreline Fringe of Switchgrass, 50% of Safety Bench Perimeter
E: Wildlife Trees and Shrubs in Bugger
F: Maintain Grass Cover on Embankment (No Trees)

Figure 2. Examples of shallow marsh planting strategies (adapted from Schueler, 1987).

Table 1. Wetland plant species (Schueler, 1987).

Plant Name	***Zone***	***Form***	***Tolerance for Periodic Inundation***	***Comments***
Arrow Arum/ Duck Corn (Peltandra virginica)	2	Emergent	to 1 ft depth	Slow colonizer
Arrowhead/ Duck Potato (Saggitaria latifolia	2	Emergent	to 1 ft to 1.5 ft depth	Aggressive colonizer
Buttonbush (Cephalanthus occidentalis)	2, 3	Emergent	to 2 ft depth	Full sun required
Broomsedge (Andropogon virginianus)	2, 3	Perimeter	to 3 in depth	Tolerates fluctuating water levels
Cattail (Typha spp.)	2, 3	Emergent	to 1 ft depth	Volunteer, aggressive colonizer
Coontail (Ceratophyllum demersum)	1	Submergent	1 ft to 6 ft deep	
Common Three-Square (Scirpus americanus)	2	Emergent	to 6 in deep	Fast colonizer, tolerates fluctuating water levels
Lizard's Tale (Saururus cernuus)	2	Emergent	to 1 ft	Rapid growing, shade tolerant
Marsh Hibiscus (Hibiscus moscheutos)	2, 3	Emergent	to 3 in	
Pickerelweed (Pontederia cordata)	2, 3	Emergent	to 0.5 ft to 1.0 ft	
Pond Weed (Potamegaton)	2, 3	Submergent	1.5 ft to 3.0 ft deep	
Rice Cutgrass (Leersia oryzoides)	2, 3	Emergent	to 3 in deep	Shade tolerant
Sedges (Cyperus spp.)	2, 3	Emergent	to 3 in deep	
Soft-stem Bulrush (Scirpus validus)	2, 3	Emergent up to 3 m	to 1.0 ft	Aggressive colonizer
Smartweed (Polygonum spp.)	2	Emergent	to 1 ft deep	Fast colonizer
Spatterdock (Nuphar luteum)	2	Emergent	to 1.5 ft	Fast colonizer, deals with fluctuating water levels
Switchgrass (Panicum virgatum)	2, 3, 4, 5, 6	Perimeter emergent	to 3 in deep	Tolerates wet/dry conditions
Sweet Flag (Acorus calamus)	2, 3	Perimeter emergent 2 to 4.5 ft.	to 3 in deep	Slow colonizer, tolerates drying
Water Iris (Iris pseudoacorus)	2, 3	Perimeter	to 3 in deep	Attractive, ornamental
Water Cress (Nasturtium officianale)	Flowing water		to 6 in deep	

Zones listed in table:

1. Deep water pool (1 ft to 6 ft deep).
2. Shallow water bench (6 in to 12 in deep).
3. Shoreline fringe (regularly inundated).
4. Riparian fringe (periodically inundated).
5. Floodplain terrace (infrequently inundated).
6. Upland slopes (seldom or never inundated).

The vegetation planted in and around the wetland should correspond to the hydrology of the wetland. This information is unique to specific geographic locations. Topsoiling of the surface prior to planting may not always be necessary. The wetland plants themselves often produce a substantial amount of organic matter below the ground. Topsoiling may be needed if the soils are composed of mainly clay, rock, or pyretic soils. Although KY-31 Tall Fescue has often been used to reduce erosion, it may displace native grass and meadow species, and possibly overtake some of the wetland. Use of this grass type is questionable because of its aggressive nature (The Center for Watershed Protection, 1994).

Vegetation Management in Constructed Wetlands

One of the goals of San Diego County, Vector Surveillance and Control is to minimize vector production while employing a minimum of pesticides. In order to achieve this goal, it is essential that effective and timely vegetation maintenance practices be employed.

Vector breeding commonly occurs in areas of high vegetation density, which are impenetrable to mosquito fish. The shallow design of a wet basin is highly conducive to invasion by dense emergent vegetation (i.e., cattails). To limit the use of pesticides, the efficacy of mosquito fish predation must be enhanced. Every provision should be made to manage emergent vegetation, thereby, ensuring the site does not become a threat to public health.

The vegetation maintenance requirements summarized below should be sufficient to maintain adequate predation and prevent excessive vector breeding. These requirements also provide vector technicians with adequate access to the water surface for routine monitoring and, when necessary, chemical abatement.

The following are guidelines for the control of vegetation at the wet basin are:

1.) Remove wet basin emergent vegetation semi-annually (early Spring and Fall) or as recommended by San Diego County, Vector surveillance and control.

2.) No more than 50% of the surface area of any standing water shall have emergent vegetation, e.g. cattails, sedges, etc.

3.) Emergent vegetation can be controlled by pulling, either mechanically or by hand; or frequent clear cutting. Pulling the vegetation, is recommended rather than cutting, as it tends to grow back more quickly and at greater density after cutting. Herbicides may be used as needed to control re-growth. Vegetation provides mosquito larvae a better habitat and refuge from predation by mosquito fish.

4.) An alternative to complete clean-outs would be to remove swaths or patches of vegetation such that no patch grows so dense as to exclude mosquito-eating fish. These cleanouts need to be conducted every 3 months. No stand of cattails shall be any larger than twenty feet wide by 10 feet deep (200 square feet). All cattail stands need to be separated by 10 feet of non-vegetative water.

5.) Remove silt as needed to maintain proper water depth.

6.) Construct and maintain foot pathways around the pond perimeter and to the water. Pathways are necessary for proper surveillance and abatement methods. Pathways should be a minimum of five ft. wide to allow access to the water without disturbing the emergent vegetation. This can cause mosquito larvae to submerge, thereby escaping detection. Include a perimeter road able to accommodate entry and maneuvering of vehicles and/ or trailers. At least one pathway to the water should be a minimum of 10 feet wide with a ramp extending below the water's surface to accommodate the use of vegetation harvesting equipment or the launch of a boat if needed for chemical application in larger BMPs.

7.) In the event larvicide must be applied, the County has and will provide up to date MSDS documents for all chemicals use in the wet basin.

8.) Wet basin construction should include barriers such as, fences or walls, to prevent entry of any unauthorized persons. Open bodies of water will often attract the attention of people who in turn, release game fish, which predate upon the mosquito fish.

9.) Wet basins should be constructed with 2:1 slope and maintain a minimum four foot depth to contain vegetation within the prescribed zone.

The above vegetation maintenance plan will both suppress vector production and facilitate the County's monitoring and abatement efforts.

REFERENCES

1. L. N. Boutiette and C. L. Duerring, 1994. *Massachusetts Nonpoint Source Management Manual, The Megamanual: A Guidance Document for Municipal Officials*, Massachusetts Department of Environmental

Protection, Office of Watershed Management, Nonpoint Source Program, Boston, MA.

2. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

3. The Center for Watershed Protection, 1994. *Watershed Protection Techniques*, Vol. 1 No. 2, The Center for Watershed Protection, Silver Spring, MD.

4. M. E. Dormann, J. Hartigan, and B. Maestri, 1988. *Retention, Detention, and Overland Flow for Pollutant Removal from Highway Stormwater Runoff: Interim Guidelines for Management Measures*, FHWA/RD-87/056, Federal Highway Administration, Versar, Inc., Springfield, VA.

5. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

6. W. J. Mitsch and J. G. Gosselink, 1993. *Wetlands*, Van Nostrand Reinhold, New York, NY.

7. T. R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.

8. B. R. Urbonas, J. T. Doerfer, J. Sorenson, J. T. Wulliman, and T. Fairley, 1992. *Urban Storm Drainage Criteria Manual, Volume 3 - Best Management Practices, Stormwater Quality, Urban Drainage and Flood Control District*, Denver, CO.

9. Ventura Countywide Stormwater Quality Management Program, *Draft BMP CW: Constructed Wetlands*, June 1999. Ventura, CA.

F.5 Drainage Inserts

(This information is derived from the Los Angeles County SUSMP)

DESCRIPTION

A catch basin insert is any device that can be inserted into an existing catch basin design to provide some level of runoff contaminant removal. Currently, there are many different catch basin insert models available, with applications ranging from trash and debris removal to carbon adsorption of aliphatic and aromatic hydrocarbons and heavy metals removal. Costs vary widely, ranging from about $40 for a simple screen bag, to over $3,000 for more complex, custom-engineered units. The most frequent application for catch basin inserts is for reduction of sediment, oil, and grease levels in stormwater runoff. These catch basin inserts should also have an overflow outlet, through which water exceeding the treatment capacity can escape without flooding the adjacent area.

ADVANTAGES

1. Provides moderate removal of larger particles and debris as pretreatment.
2. Low installation costs.
3. Units can be installed in existing traditional stormwater infrastructure.
4. Ease of installation.
5. Requires no additional land area.

LIMITATIONS

1. Vulnerable to accumulated sediments being resuspended at low flow rates.
2. Severe clogging potential if exposed soil surfaces exist upstream.
3. Maintenance and inspection of catch basin inserts may be required before and after each rainfall event, excessive cleaning and maintenance.
4. Available head to meet design criteria.
5. Dissolved pollutants are not captured by filter media.
6. Limited pollutant removal capabilities.

DESIGN CRITERIA

1. Calculate the flow rate of stormwater to be mitigated by the catch basin insert using Principle 8: Design to Treatment Control BMP Standards in the *County of San Diego Standard Urban Stormwater Mitigation Plan Guidance Manual*.
2. Insert device selected should be Best Available Technology for removing constituents of concern for the particular site.

REFERENCES

1. The Center for Watershed Protection, Environmental Quality Resources and Loiederman Associates. 1997. *Maryland Stormwater Design Manual*. Prepared for: Maryland Department of the Environment. Baltimore, MD.

2. DEQ Storm Water Management Guidelines, Department of Environmental Quality, State of Oregon. http://waterquality.deq.state.or.us/wq/groundwa/swmgmtguide.htm

3. K. H. Lichten, June 1997. *Compilation of New Development Stormwater Treatment Controls in the San Francisco Bay Area*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

F.6 Filtration Systems

(This information is derived from the Los Angeles County SUSMP)

DESCRIPTION OF SAND FILTERS

Media filters are two-stage constructed treatment systems, including a pretreatment settling basin and a filter bed containing sand or other filter media. Various types of sand filter designs have been developed and implemented successfully in space-limited areas. The filters are not designed to treat the entire storm volume but rather the water quality volume (WQV), which tends to contain higher pollutant levels. Sand filters can be designed so that they receive flow directly from the surface (via inlets or even as sheet flow directly onto the filter bed) or via storm drain pipes. They can be exposed to the surface or completely contained in underground pipe systems or vaults.

While there are various designs, most intermittent sand filters contain four basic components, as shown schematically in Figure 1 and discussed below:

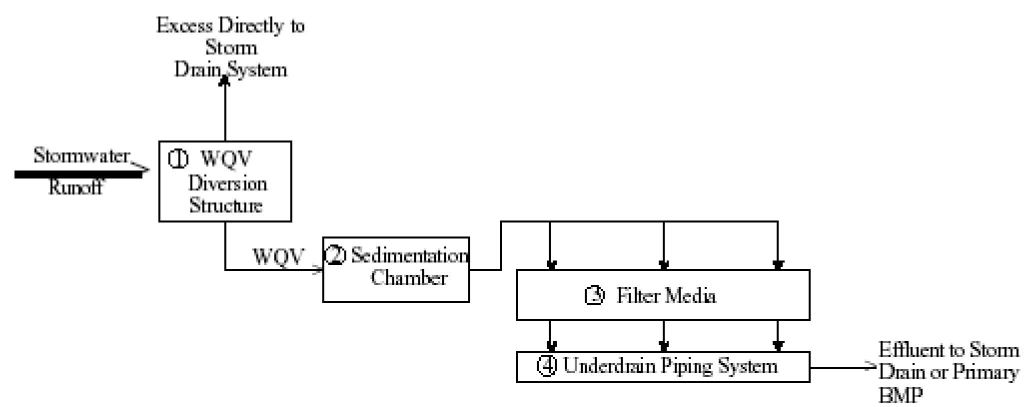


Figure 1. Schematic of a typical sand filter.

1. *Diversion Structure.* Either incorporated into the filter itself or as a stand-alone device, the diversion structure isolates the WQV and routes it to the filter. Larger volumes are bypassed directly to the storm drain system.
2. *Sedimentation Chamber.* Important to the long-term successful operation of any filtration system is the removal of large grained sediments prior to exposure to the filter media. The sedimentation chamber is typically

integrated directly into the sand filter BMP but can also be a stand-alone unit if space permits.

3. *Filter Media.* Typically consists of a 1-inch gravel layer over an 18 to 24 inch layer of washed sand. A layer of geotextile fabric can be placed between the gravel and sand layers.
4. *Underdrain System.* Below the filter media is a gravel bed, separated from the sand by a layer of geotextile fabric, in which is placed a series of perforated pipes. The treated runoff is routed out of the BMP to the storm sewer system or another BMP.

ADVANTAGES

1. May require less space than other treatment control BMPs and can be located underground.
2. Does not require continuous base flow.
3. Suitable for individual developments and small tributary areas up to 100 acres.
4. Does not require vegetation.
5. Useful in watersheds where concerns over groundwater quality or site conditions prevent use of infiltration.
6. High pollutant removal capability.
7. Can be used in highly urbanized settings.
8. Can be designed for a variety of soils.
9. Ideal for aquifer regions.

LIMITATIONS

1. Given that the amount of available space can be a limitation that warrants the consideration of a sand filter BMP, designing one for a large drainage area where there is room for more conventional structures may not be practical.
2. Available head to meet design criteria.
3. Requires frequent maintenance to prevent clogging.
4. Not effective at removing liquid and dissolved pollutants.
5. Severe clogging potential if exposed soil surfaces exist upstream.
6. Sand filters may need to be placed offline to protect it during extreme storm events.

DESIGN CRITERIA

1. Calculate the flow rate of stormwater to be mitigated by the catch basin insert using Principle 8: Design to Treatment Control BMP Standards in the *County of San Diego Standard Urban Stormwater Mitigation Plan Guidance Manual*.
2. *Surface area of the filter.* The following equation is for a maximum filtration time of 24 hours:

   A. Surface Systems or Vaults
   Filter area (ft_2) = $3630S_uAH/K(D+H)$

Where: S_u = unit storage (inches-acre)
A = area in acres draining to facility
H = depth (ft) of the sand filter
D = average water depth (ft) over the filter taken to be one-half the difference between the top of the filter and the maximum water surface elevation
K = filter coefficient recommended as 3.5

This equation is appropriate for filter media sized at a diameter of 0.02 to 0.04 inches. The filter area must be increased if a smaller media is used.

B. Underground Sandfilter Systems

a. Compute the required size of the sand filter bed surface area, A_F. The following equation is based on Darcy's law and is used to size the sand filter bed area:

A_F (ft^2) = 24(WQV)(d_f)/ [k (h_f + d_f) t_f]

Where: A_f = sand filter bed surface area (ft^2)
WQV = Water quality treatment volume (ft^3)
d_f = sand filter bed depth (ft)
k = filter coefficient recommended as 3.5 (ft/day)
h_f = average height of water above the sand bed (ft)
= $h_{max}/2$
h_{max} = elevation difference between the invert of the inlet pipe and the top of the sand filter bed (ft)
t_f = time required for the runoff to filter through the sand bed (hr). (Typically 24 hr).
Note: 24 in the equation is the 24hr/day constant.

b. Choose a pipe size (diameter). The selection of pipe size should be based on site parameters such as: elevation of the runoff coming into the sand filter system, elevation of downstream connection to which the sand filter system outlet must tie into, and the minimum cover requirements for live loads. A minimum of 5' clearance should be provided between the top of the inner pipe wall and the top of the filter media for maintenance purpose. Use:

D = d + 5

Where: D = pipe diameter (ft)
d = depth of sand filter and underdrain pipe media depth (ft)
= d_g + d_f
d_g = underdrain pipe media depth = 0.67’
d_f = sand filter bed depth (ft): 1.5 to 2.0 feet

c. Compute the sand filter width (based on the pipe geometry):

$$W_f = 2 [R^2 - (R - d)^2]^{0.5}$$

Where: W_f = filter width (ft)
R = pipe radius (ft)
= D/2

d. Compute the filter length:

$$L_f = A_f / W_f$$

Where: L_f = filter length (ft)

3. *Configuration*

A. Surface sand filter

Criteria for the settling basin.

a. For the outlet use a perforated riser pipe.
b. Size the outlet orifice for a 24 hour drawdown
c. Energy dissipator at the inlet to the settling basin.
d. Trash rack at outlets to the filter.
e. Vegetate slopes to the extent possible.
f. Access ramp (4:1 or less) for maintenance vehicles.
g. One foot of freeboard.
h. Length to width ratio of at least 3:1 and preferably 5:1.
i. Sediment trap at inlet to reduce resuspension.

Criteria for the filter.

a. Use a flow spreader.
b. Use clean sand 0.02 to 0.04 inch diameter.
c. Some have placed geofabric on sand surface to facilitate
d. Maintenance.
e. Underdrains with:
   - Schedule 40 PVC.
   - 4-inch diameter.
   - 3/8-inch perforations placed around the pipe, with 6 inch space between each perforation cluster.
   - maximum 10 foot spacing between laterals.
   - minimum grade of 1/8-inch per foot.

B. Underground sand filter

Criteria for the settling tank (if required).

a. Use orifice and/or weir structure for the outlet.
b. Size the outlet orifice or weir for a 24 hour drawdown time

c. Provide access manhole for maintenance.

Criteria for the filter.

a. Use a flow spreader.
b. Use clean sand 0.02 to 0.04 inch diameter.
c. Some have placed geofabric on sand surface to facilitate maintenance.
d. Underdrains with:
   - Schedule 40 PVC.
   - 4-inch diameter
   - 3/8-inch perforations placed around the pipe, with 6-inch pace between each perforation cluster.
e. Provide access manhole for maintenance.

REFERENCES

1. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board. Alameda, CA.

2. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

3. B. R. Urbonas, January/February 1999. *Design of a Sand Filter for Stormwater Quality Enhancement*, Water Environment Research, Volume 71, Number 1. Denver, CO.

4. Ventura Countywide Stormwater Quality Management Program, *Draft BMP MF: Media Filters*, June 1999. Ventura, CA.

5. Northern Virginia BMP Handbook, City of Alexandria Virginia, February 1992. Alexandria, VI.

6. US EPA, Developments in Sand Filter Technology to Improve Runoff Quality, www.epa.gov/owowwtr1/NPS/wpt/wpt02/wpt02fa2.html.

F.7 Hydrodynamic Separation Systems

There are different types of hydrodynamic separators approved for use by the County. The following is a guideline for three of these approved BMPs.

F.7.1 CDS

The CDS Technology was developed as a gross pollutant trap and is a proprietary product manufactured under patents by CDS Technologies, Inc. The technology captures and retains floatables, trash and debris greater than 0.05 inch in stormwater runoff, as well as capture of fine sand and larger particles and the pollutants attached to those particles. The CDS unit is a non-mechanical self-operating system and will function when there is flow in the storm drainage system. A cross-section of a CDS unit is shown in Figure 3.3.1. The unit is designed to capture pollutants in flows up to the design capacity and during extreme rainfall events when the designed capacity may be exceeded. Material captured in the CDS unit’s separation chamber and sump is retained even when the unit’s design capacity is exceeded.

Appropriate Applications and Siting Constraints:

CDS should be considered for implementation wherever site conditions allow.

One important siting requirement is that sufficient head is available so that water stored in the device does not cause a backwater condition in the storm drain system, which would limit its capacity.

F.7.2 GSRD

GSRDs include physical/mechanical methods of removing litter and solids 5 mm1 (0.25 inch nominal) and larger from the storm water runoff using various screening technologies. There are two devices can be considered in this BMP, Linear Radial Device (LSRD) and the Inclined Screen.

Appropriate Applications and Siting Constraints:

GSRDs should be considered for areas where receiving waterbodies are on the 303(d) impaired water body list for trash. GSRDs should also be installed in the areas where TMDLs require trash removal.

The Linear Radial Device requires very little head to operate and is well suited for narrow and relatively flat rights-of-way with limited space. The Inclined Screen requires about 1.5 m (5 ft) of head and is well suited for fill sections of the highways. These devices should have enough available space for maintenance and inspection including the use of vacuum trucks and other equipment if necessary.

Linear Radial Device

This device (Figure F-7) utilizes modular well casings with 5 mm (0.25-inch nominal) louvers to remove litter. The louvered well casings are contained in a concrete vault. Flows pass radially through the louvers trapping litter and solids in the casing and passing flows into the vault for discharge via an outlet pipe. The bottom of the casing is smooth to allow trapped litter to move to the downstream end of the well casing. The device requires very little head to operate and has been pilot tested for 1 % slope. Flatter slopes may work but have not been tested. The Linear Radial Device is designed to work in-line with the existing storm drain system or could be placed in an offline configuration. In- line configuration incorporates overflow/bypass if the unit becomes plugged. As shown in Figure 5-8, the first half-meter of the linear well casing is non louvered with an open top to allow for influent bypass should the device become clogged with litter. The circular louvered sections have access doors that can be easily opened to facilitate cleaning with a vacuum truck or other equipment if necessary. The device is covered with a load-bearing grating appropriate to the location.

1 5 mm size is based on requirements set forth in Los Angeles river watershed trash TMDL. Other sizes may be necessary as required by other TMDLs.

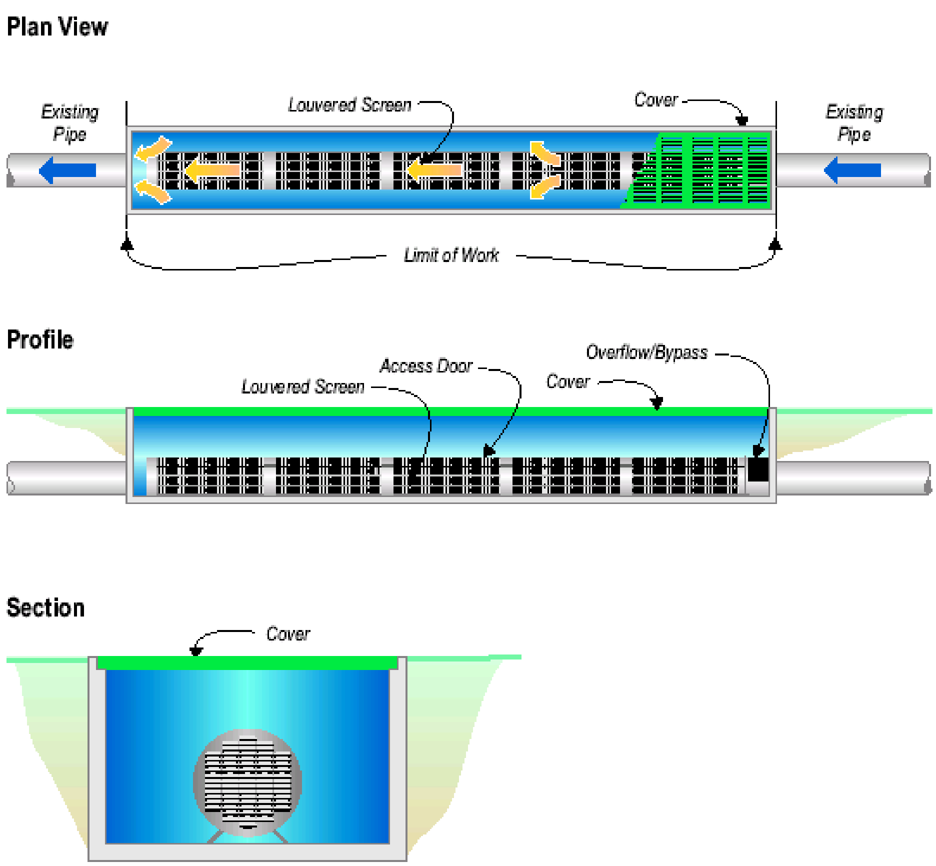


Figure F-7
Example Schematic of Linear Radial Device

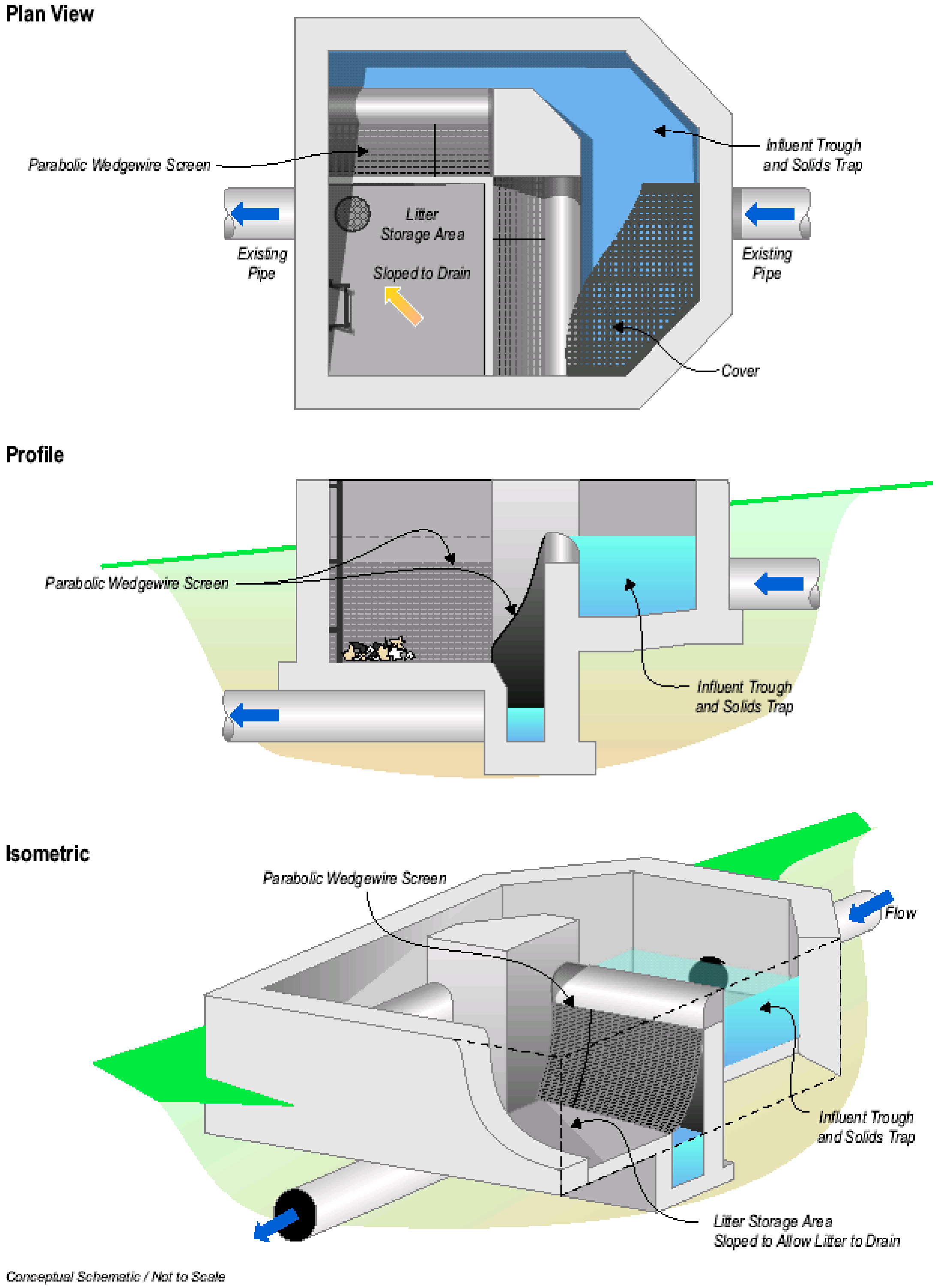
(Not a Standard Plan)

Figure F-8
Partially Full Linear Radial Device

Inclined Screen

In this device, the flow overtops a weir and falls through an inclined bar rack (wedge-wire screen) with a 3-mm (0.125-inch nominal) 2 maximum spacing between the bars, located after the influent trough. After passing through the rack the flow exits the device via the discharge pipe. A distribution trough is provided to allow influent to be distributed along the length of the Inclined Screen. The litter captured by the bar rack is pushed down toward the litter storage area by the storm water runoff. Parabolic wedge-wire screen inclined at 60 degrees and 1 m high was tested in pilot studies and worked effectively. Other configurations with different inclinations and heights of the screen may work but have not been pilot tested. In order to minimize the footprint of the device, a 90-degree elbow configuration of the screen (Figure F-9) was used in pilot study. Other configurations of the screen can be used on a site-specific basis. The gross solids storage area is sloped and is provided with a drain to prevent standing water. As shown in Figure F-9, an opening above the litter storage area is provided to allow for overflow/bypass if the device becomes plugged. The device should be designed for litter and debris storage for a period of one year. The device is covered with a load-bearing grating appropriate to the location.

2 This screen size was pilot tested; other screens sizes up to 5 mm (0.25 inch) may be used if available.



Inclined Screen GSRD

Figure F-9
Example Schematic of Inclined Screen
(Not a Standard Plan)

Figure F-10
Inclined Screen

Factors Affecting Preliminary Design:

The two most important factors affecting the design of these devices are: (1) the need to be sized to accommodate both gross pollutants storage for a given maintenance period (typically one year), and (2) the hydraulic capacity of the drainage system in which it is to be installed. Litter and debris accumulation data needs to be available to properly size the devices for the given drainage area. These devices can be designed both in and offline. In-line configuration incorporates overflow/bypass if the unit becomes plugged. A summary of preliminary design factors is presented in table 5-10.

TABLE F.10: SUMMARY OF GROSS SOLIDS REMOVAL DEVICES (LINEAR RADIAL AND INCLINED SCREEN)

Description	Applications/Siting	Preliminary Design Factors
Treatment Mechanisms: • Filtration through screens Pollutants removed: • Litter and solid particles greater than 5 mm (0.25 inch nominal)	• Site conditions must have adequate space for device and maintenance activities. • Sites that drain to litter sensitive receiving waters on 303(d) list for trash or areas where TMDLs require trash removal. • The Linear Radial Device requires little head to operate and is well suited for flat sections of highway.	• Regional litter accumulation data are desirable, otherwise use 0.7 m3/hectare/year. • Devices must be sized for peak design flow while carrying design gross solids load. • The Linear Radial Device well casing is available up to 900 mm (36 inch) diameter. • Devices can be placed in-line incorporating bypass/overflow or it may be placed offline. • The Inclined Screen requires 1.5 m (5 ft) of head and it is well suited for fill sections.